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Nine new species of the *Eremobates scaber* species group of the North American camel spider genus *Eremobates* (Solifugae, Eremobatidae)

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Abstract

Nine new species of the *Eremobates scaber* species group of the solifuge genus *Eremobates* Banks 1900 are described, eight of them from Mexico. These new species are: *E. axacoa*, *E. bonito*, *E. cyranoii*, *E. fisheri*, *E. hidalgoana*, *E. jaliscoana*, *E. minamoritaana*, *E. zacatecana*, and *E. zapal* and together increase the size of this species group to 23. A key to all species in the *E. scaber* species group is also provided.

Key words: Camel spider, solifugid, revision, taxonomy

Introduction

Solifugae, commonly known as camel spiders, is a poorly studied order of arachnids. It currently includes 12 families and over 1,100 described species. The phylogeny of the order and of all but one family is currently unresolved. In recent years, our lab has focused on the phylogeny, biology, and natural history of the North American family Eremobatidae Kraepelin 1899 (Brookhart & Cushing 2002, 2004, 2005; Cushing *et al.* 2005, 2014, 2015; Conrad & Cushing 2011; Cushing & Casto 2012). Cushing *et al.* (2015) produced a backbone molecular phylogeny of the Eremobatidae that supported the monophyly of several genera and species groups within the family. The *Eremobates scaber* species group was well supported but was made paraphyletic with respect to *Hemerotrecha sevilleta* Brookhart & Cushing 2002 (Cushing *et al.* 2015). However, the *H. sevilleta* specimen used in that analysis was missing data and none of the available specimens of this species of *Hemerotrecha* was well preserved. Thus, we suspect that rather than indicating that the *E. scaber* group is artificial, the placement of *H. sevilleta* in this clade indicates that a re-assessment of that species, once additional better-preserved specimens are collected, is necessary. In this paper, we build upon our understanding of this species group.

Brookhart & Cushing (2004) produced an analysis of the *E. scaber* species group including the description of three new species, the synonymization of two species, and identification of both sexes for 12 of the 14 species then known. We also produced a phylogeny of this species group based on morphological characters, the first for any solifuge taxon. In the Cushing *et al.* (2015) analysis, the *E. scaber* species group clade (which included *H. sevilleta*) was strongly supported in both the Bayesian and Maximum Likelihood analyses.

The *E. scaber* species group currently includes: *E. actenidia* Muma 1989, *E. ascopulatus* Muma 1951, *E. clarus* Muma 1989, *E. corpink* Brookhart & Cushing 2004, *E. ctenidiellus* Muma 1951, *E. hodai* Muma 1989, *E. icenoglei* Brookhart & Cushing 2004, *E. legalis* Harvey 2002, *E. mormonus* (Roewer 1934), *E. paleta* Brookhart & Cushing 2005, *E. scaber* (Kraepelin 1899), *E. similis* Muma 1951, *E. soccal* Brookhart & Cushing 2004, and *E. zinni* Muma 1951. The group was erected by Muma (1951) to encompass those species of *Eremobates* whose males were characterized by a broad basal notch occupying one-third or more of the length of the fixed finger in dorsal view (Fig. 1A, arrow). In the *E. scaber* species group the mesoventral groove (MVG) is deep and narrow (Fig. 1B). The female genital operculum is roughly triangular (Fig. 1C) with species distinguished by differences in the medial margins. In their molecular phylogenetic analysis of Eremobatidae, Cushing *et al.* (2015) found that the *E.*

scaber species group was phylogenetically and geographically cohesive. This species group diversified during the Pliocene (Cushing *et al.* 2015). Increasing aridification in the middle Miocene and beyond is thought to have generated a large, contiguous expanse of proto-desert across what is now the Mojave, Sonoran, and Chihuahuan deserts (Morafka 1977) and likely led to the diversification of many arid-adapted taxa, including many species of solifuges (Cushing *et al.* 2015).

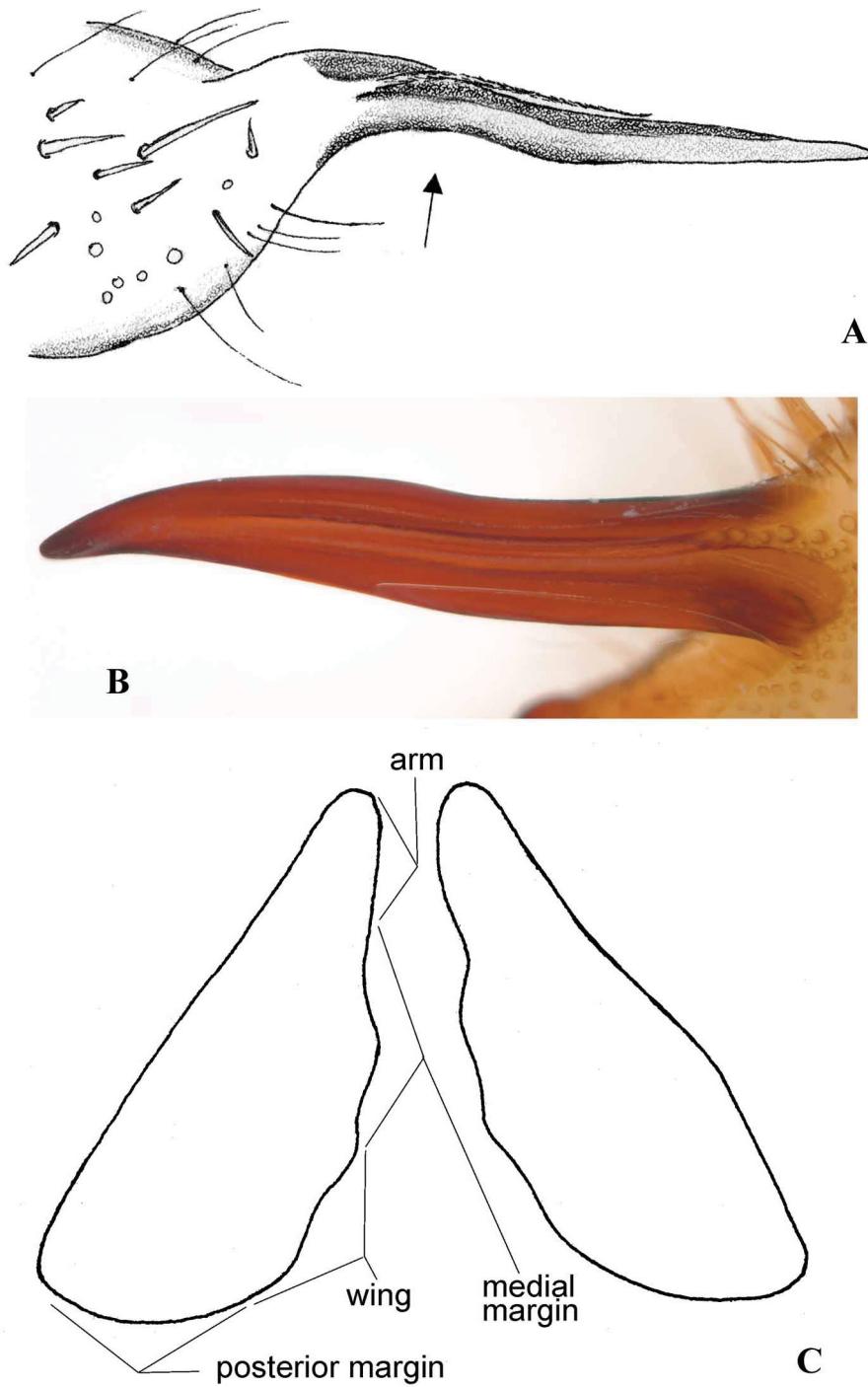


FIGURE 1. Diagnostic synapomorphies of the *Eremobates scaber* species group (A and C taken from Brookhart & Cushing 2004). A) Dorsal view of cheliceral fixed finger of male, arrow indicating deep basal notch. B) Deep, narrow mesoventral groove on the male cheliceral fixed finger. C) Roughly triangular-shaped female genital operculum of this species group.

The majority of species in this group are found in piñon pine-juniper or desert shrub communities of the arid USA. *Eremobates paleta* and *E. legalis* both have type localities in Mexico (Brookhart & Cushing 2004, 2005;

Brookhart & Brookhart 2006); all the rest were first described from the USA. However, Vásquez-Rojas (1981) recorded *E. zinni* from Mexico and Muma (1951, 1987) listed *E. ctenidiellus* and *E. geniculatus* from Mexico. The latter record was found to have resulted from a misidentification of *E. mormonus* by Muma (1951) (Brookhart & Cushing 2004). Seven genera and 64 species of solifuges have been identified from Mexico (Brookhart & Brookhart 2006; Ballesteros & Francke 2008), and it is likely that more species of the *E. scaber* species group range into the Chihuahuan Desert region of Mexico.

Muma (1951, 1962, 1970, 1987, 1989) used length vs. width of the fondal notch, number and shape of ctenidia, and number of palpal papillae, as well as coloration of appendages to separate each species within the *E. scaber* species group. The number of ctenidia range from none to six. The palpal scopula varies from none to over 120 papillae. Females are identified by the structure of the genital operculum and coloration of appendages. Coloration of the eye tubercle and malleoli are consistently the same for all species with eye tubercles dark and malleoli white. Abdominal coloration varies from a pale yellow to a grey background dorsally and ventrally with lighter pleural membranes and is a poor character to use for species identification. Many specimens have tergites with a rectangular, violet-brown pigmentation which gives the appearance of a broad stripe to many specimens. Muma (1951) calls this a sclerite although it is not particularly thick or hardened. It was not found to be diagnostic in this study.

Throughout this paper, we follow the cheliceral terminology suggested by Bird *et al.* (2015) except for fondal teeth. We maintain Muma's (1951) use of Roman numerals designating the location and relative size of fondal teeth since this designation is less cumbersome and more adequately expresses relative size than the terminology proposed by Bird *et al.* (2015).

Typical male chelicerae in the *Eremobates scaber* species group is characterized by the broad basal notch of the cheliceral fixed finger in dorsal view (Fig. 1A, arrow). There are no median series teeth (per Bird *et al.* 2015) on the fixed finger and some variation in the shape of the fixed finger in retrolateral view. The movable finger follows the general pattern of a large proximal tooth (MP), two submedial teeth (MSM) (the proximal being larger) and a medial tooth (MM) (Fig. 2). The medial tooth is distinctively flattened and frequently has a cleft beneath the anterior face. The movable finger prolateral tooth (MPL, not visible in Fig. 2) varies from tiny to absent. The fondal notch is "U" shaped but some variation is evident. Zero to three retrofondal teeth are present. Female chelicerae have a fixed finger with teeth in the following order (proximal to distal): 0–3 retrofondal teeth (RF), a large proximal tooth (FP), two submedial teeth (FSM), a medial tooth (FM), a single subdistal tooth (FSD), and smaller distal tooth (FD) (see plate 21, Bird *et al.* 2015 and Figs. 5 I–L). The female movable finger has a large proximal tooth (MP); two submedial teeth (MSM), the posterior of which is larger; and a large medial tooth (MM). The prolateral tooth (MPL) varies from absent to medium sized (Fig. 5 I–L). Fondal teeth in both males and females grade out (apex to base) I, III, II, IV in size although in some species the fondal tooth III is equal in size to fondal tooth I (Fig. 6). Due to wear, the medial teeth on both male and female movable fingers are sometimes hard to diagnose.

While examining the solifuge collection from the Instituto de Biología Universidad Nacional Autónoma de México (IBUNAM), Mexico City, courtesy of Oscar Francke, we discovered nine new members of the *E. scaber* species group, most of which are represented by singletons. However, because this species group is diagnosable based upon distinct morphological synapomorphies (e.g., the broad basal notch of the male fixed finger), we felt confident in placing these single specimens into the *E. scaber* species group. Additionally we have discovered one new species from California, USA that is deposited in the collection at the Denver Museum of Nature & Science (DMNS) that was collected by staff with the U.S. Geological Survey (USGS).

Material and methods

We used the methods described in Muma (1951), Brookhart & Muma (1981, 1987), Muma & Brookhart (1988), and Brookhart & Cushing (2004). We recorded the following measurements either directly from the specimens or using an Olympus SZX12 microscope: total length of palpus, leg I, and leg IV; length of palpal tarsus and of palpal metatarsus; length and width of chelicera; width of base of fixed finger; and length of propeltidium. All measurements are in millimeters. Ratios used previously by Brookhart & Cushing (2002, 2004) were computed. These ratios are as follows: A/CP: the sum of the lengths of palpus, leg I, and leg IV divided by the sum of length

of chelicera and propeltidium indicating length of appendages in relation to body size. Long-legged species have larger A/CP ratios. FFH/FNH (Fig. 2) indicates whether the fixed cheliceral finger of the male is thin or robust in relation to the size of the chelicera. We used the terminology of Bird *et al.* (2015) in referencing prolateral cheliceral setae and cheliceral dentition, except for fondal teeth.

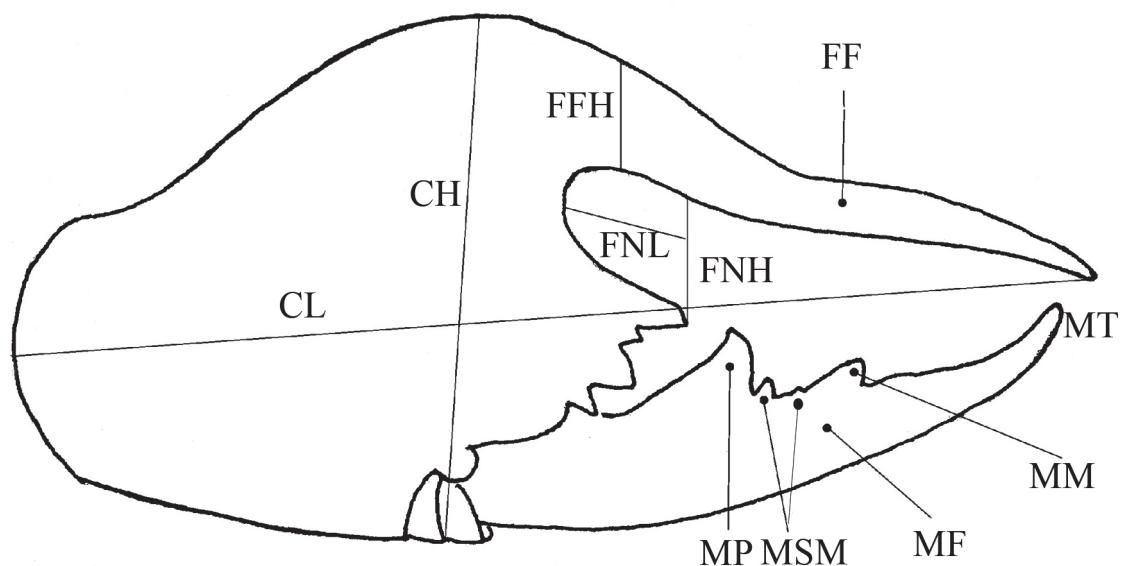


FIGURE 2. Typical tooth pattern of the chelicera of male *Eremobates scaber* species group. Figure reproduced from Brookhart & Cushing (2004) but abbreviations from Bird *et al.* (2015). CH—cheliceral height; CL—cheliceral length; FF—fixed finger; FFH—fixed finger height; FNH—fondal notch height; FNL—fondal notch length; MF—movable finger; MM—movable finger, medial tooth; MP—movable finger, proximal tooth; MSM—movable finger, submedial teeth; MT—movable finger, terminal tooth.

Abbreviations as follows (Fig. 2): CL—chelicera length; CH—chelicera height; FNL—fondal notch length; FNH—fondal notch height; FFH—fixed finger height; LI—first leg length; LIV—fourth leg length; PPL—propeltidium length; PL—palpus length; PMT—palpal metatarsus length; PT—palpal tarsal length; TL—total length measured from distal tip of chelicera to posterior edge of the abdomen, although total length is skewed depending on distension of the abdomen (Muma & Brookhart 1988). Cheliceral tooth character abbreviations are: FD—fixed finger, distal tooth; FM—fixed finger, medial tooth; FP—fixed finger, proximal tooth; FSD—fixed finger, subdistal tooth/teeth; FSM—fixed finger, submedial tooth; MM—movable finger, medial tooth; MP—movable finger, proximal tooth; MSM—movable finger, submedial tooth; RFA—retrofondal anterior teeth; RF—retrofondal teeth. Cheliceral setal pattern as illustrated by Bird *et al.* (2015): mff—short plumose setae overlapping the fond when the chelicerae are closed (see plates 12A and 13A) in Bird *et al.* 2015; mpd—prolateral setae lining the dorsal margin of the setose area on the movable finger ventral to the asetose area (plates 12A, 13A, and 14A in Bird *et al.* 2015); pvd—rows of usually plumose setae lining the ventral margin of the fixed finger from the base to the apex; sfc—setiform flagellar complex. Cheliceral measurements are illustrated in Fig. 2.

Examination of the setation of the palpal tibia and femur is listed although it did not prove diagnostic for this group. We also examined the retrofondal teeth (RF) on the basal fondal membrane, and the retrofondal anterior teeth (RFA).

In order to facilitate inter-specific comparisons among the new taxa, we have grouped illustrations of similar morphological structures into the same figure plates (Fig. 3–9). In the following key to the *E. scaber* species group males (females are more difficult to separate), lowercase “fig” refers to figures in Brookhart & Cushing 2004 whereas uppercase “Fig” refers to figures in this paper.

Key to the males of the *Eremobates scaber* species group

1	No ctenidia or ctenidia very thin and barely discernable from surrounding setae	2
-	Ctenidia present and distinct	7
2	Palpal papillae absent	3
-	Palpal papillae present	4
3	Two tiny MSM; small, short fondal notch; ventral setal complex (<i>mpd</i>) typical (Fig. 5O & P)	<i>E. minamoritaana</i>
-	One MSM in notch of proximal tooth; long fondal notch; ventral setal complex a proximal patch (<i>mff</i>) (Fig. 6Q & R)	<i>E. zacatecana</i>
4	Large "J" shaped fondal notch; tiny fondal teeth (Fig. 5A)	5
-	Fondal notch "U" shaped; prominent fondal teeth (Fig. 5M)	6
5	Overall dusky yellow; one MSM separate from proximal tooth (fig. 30)	<i>E. actenidia</i>
-	Overall dark brownish-violet; two MSM, the posterior in the notch of principal tooth (Fig. 5A & B)	<i>E. axacoa</i>
6	Propeltidium unmarked, dusky yellow (Fig. 3G); FF basal notch only slightly curved in dorsal view (Fig. 4E) ..	<i>E. jaliscoana</i>
-	Propeltidium with mottled brownish-violet color covering most of propeltidium except for a thin, pale yellow strip extending from ocular tubercle to posterior edge (fig. 48); typical basal notch of FF in dorsal view (similar to Fig. 1A) ..	<i>E. ctenidiellus</i>
7	Two ctenidia	8
-	Four ctenidia	12
8	Cleft under MM; FF crimped visibly in retrolateral view	9
-	No cleft under MM; thin FF, not noticeably crimped in retrolateral view	10
9	Long fondal notch (fig. 31); large fondal teeth	<i>E. scaber</i>
-	Short fondal notch (fig. 33); small fondal teeth	<i>E. clarus</i>
10	Overall coloration lemon yellow; ctenidia flat and sword-shaped (fig. 40)	<i>E. hodai</i>
-	Overall coloration dusky yellow, brown, or brownish-violet; ctenidia thin, needle-like (fig. 43)	11
11	Cleft under MM tooth (fig. 21); fondal notch higher than long; ctenidia short and thin (fig. 24); palpal tarsus and metatarsus brownish-violet	<i>E. corpink</i>
-	No cleft under MM tooth (fig. 35); fondal notch equal in length and width; palpal tarsus and metatarsus dusky yellow; ctenidia flat, needle-like (fig. 43)	<i>E. ascopulatus</i>
12	Palpal papillae absent	13
-	Palpal papillae present	16
13	FF turned up sharply (Fig. 5E, F); MVG deep and anteriorly oriented (Fig. 5C)	<i>E. cyranoi</i>
-	Typical FF	14
14	Normal medial tooth present (fig. 28); palpal tarsus, metatarsus, tibia, and tibia-femoral joint brownish-violet	<i>E. similis</i>
-	Medial tooth tiny, absent, or a slight ridge present	15
15	Propeltidium unmarked, dusky yellow (Fig. 3J); appendages the same; no visible medial tooth (Fig. 5S, T); one secondary tooth in notch of proximal tooth (Fig. 5S)	<i>E. zapal</i>
-	Propeltidium marked by brownish-violet coloration anteriorly and laterally (fig. 4); palpal tarsus, metatarsus, tibia, and tibia-femoral joint brownish-violet; FSM tooth tiny (fig. 5)	<i>E. icenoglei</i>
16	Cleft under medial tooth	17
-	No cleft under medial tooth	18
17	Palpal tarsus and metatarsus dusky yellow; propeltidium marked with thin brownish-violet anterior edge (fig. 50); three to four stiletto-shaped ctenidia extending half the length of succeeding sternite (fig. 39)	<i>E. zinni</i>
-	Palpal tarsus and metatarsus dusky brownish-violet (fig. 13); propeltidium dark brownish-violet except for lighter medial area (fig. 10); four flat ctenidia (fig. 14)	<i>E. socal</i>
18	Propeltidium dusky yellow with no discernable markings (Fig. 3D); ctenidia thin, stiletto-like, extending more than half the length of succeeding sternite (Fig. 8C)	<i>E. fisheri</i>
-	Propeltidium and palps with discernable markings	19
19	Propeltidium with dusky amber patches on lateral, anterior half (fig. 51); palpal tarsus and metatarsus dusky amber; ctenidia thin, pointed and shorter than abdominal segment (fig. 37)	<i>E. mormonus</i>
-	Propeltidium reticulate darkish brown-violet with pale thin stripe extending behind ocular tubercle (Fig. 3B); palpal tarsus, metatarsus, tibia, and apical half of femur dark brownish-purple (Fig. 7); ctenidia broad and extending length of abdominal segment (Fig. 8A)	<i>E. bonito</i>

Taxonomy

Family Eremobatidae Kraepelin

Subfamily Eremobatinae Kraepelin

Genus *Eremobates* Banks 1900

Datames Simon 1879: 113 (preoccupied).

Eremobates Banks 1900: 426 (new name for *Datames* Simon).

Eremoperna Roewer 1934: 557 (in part).

Eremopus Roewer 1934: 561 (in part).

Eremognatha Roewer 1934: 566 (in part).

Eremocosta Roewer 1934: 569 (in part).

Eremostata Roewer 1934: 571 (in part).

Type species. *Gluvia cinerascens* C.L. Koch 1842 (junior synonym of *Galeodes pallipes* Say 1923).

Muma (1951) described the genus *Eremobates* as small to medium sized Eremobatidae with a MVG that extends the entire length of the male fixed finger (Fig. 1B). The flagellum complex (*sfc*) is composed of a dorsal row of simple tubular bristles that are sometimes striate and a ventral row of S-shaped, flattened, plumose bristles that form an arch over the basal third of the MVG (*pvd*). The apical, plumose bristle of the ventral row is straight and forms a parallel covering over the apical two-thirds of the MVG.

The first post-spiracular abdominal sternite of males is with or without ctenidia. Genital operculum of female variable. This description did not change in later works (Muma 1962, 1970, 1989). Malleoli on the coxae of leg IV are always white.

Eremobates axacoa n. sp.

Figs. 3A, 4A, 5A & B, 6A

Type material. Mexico: Oaxaca, 1 km al E. de Yaqui, Municipio de Tlacolula. 19 November 2005. 1662 m elevation. N 16.51297°, W 96.25461°. Coll. O.F. Francke *et al.* Holotype male deposited at IBUNAM (CNAN-T1012).

Etymology. An anagram referring to the Mexican state of the type locality, Oaxaca. Used as a noun in apposition.

Diagnosis. *Eremobates axacoa* n. sp. resembles *E. mormonus* but is distinguished from it by lack of ctenidia and lighter coloration of appendages and full coloration of the propeltidium (Fig. 3A). The basal notch occupies less than a third of the fixed finger (Fig. 4A). The large medial tooth (MM) of the male is also unique (Figs. 5A & B).

Description. *Male holotype. Coloration.* Overall dark species; appendages lighter, yellow brown, palpal tarsus brownish-purple; leg I dark yellow, leg II femur mottled brown, legs III and IV mottled brown on femur and proximal third of the tibia. Propeltidium mottled brownish purple with a thin lighter tan line extending posteriorally (Fig. 3A). Abdomen dark dorsally and grey ventrally. Malleoli white.

Measurements. Male holotype. TL 25.5; CL 6.0 CH 2.9; FNL 1.0; FNH 0.7; FFH 0.6; PL 19.5; PT 1.3; PMT 5.0; LI 14.5; LIV 27.5; PPL 3.8; A/CP 6.3; CL/CH 2.0; FNL/FNH 1.5; FFH/FNH 1.2; PMT/PT 3.6.

Chelicera. Fixed finger basically straight with a slight apical curve; MVG typical, deep and prolaterally oriented (Fig. 5B). Movable finger with large P; two FSM, the anterior being smaller; large M that is not typical of the *E. scaber* species group (Figs. 5A & B). MPL visible (Fig. 5F). Fondal teeth graded I, III, II, IV retrolaterally and prolaterally; two barely visible RFA and 3 RF (Fig. 6A). Dorsal cheliceral setation typical, *pvd* fondal plumose setae extending to top of fondal tooth I. No plumose *mpd* but a proximal *mff* patch as in *E. zacatacana* n. sp.

Setation. Small patch of papillae on distal ventral region of palp. No paired setae on palps, scattered setae on distal end of palpal femur. No ctenidia. A few bacilli, mostly on the anterior edge of the coxa of legs II, III, IV.

Eremobates bonito n. sp.

Figs. 3B, 4B, 5C & D, 6B, 7A, 8A

Type material. Mexico: Coahuila, Sierra Parras II, ca 8 km al Sur da Parras, N 25.23055°, W 102.10843°. 21 July 2006. Colecta nocturna UV. Coll. B. Hendrixson, K. McWest, E. Gonzalez, S. Grant. Holotype male deposited at IBUNAM (CNAN-T1014).

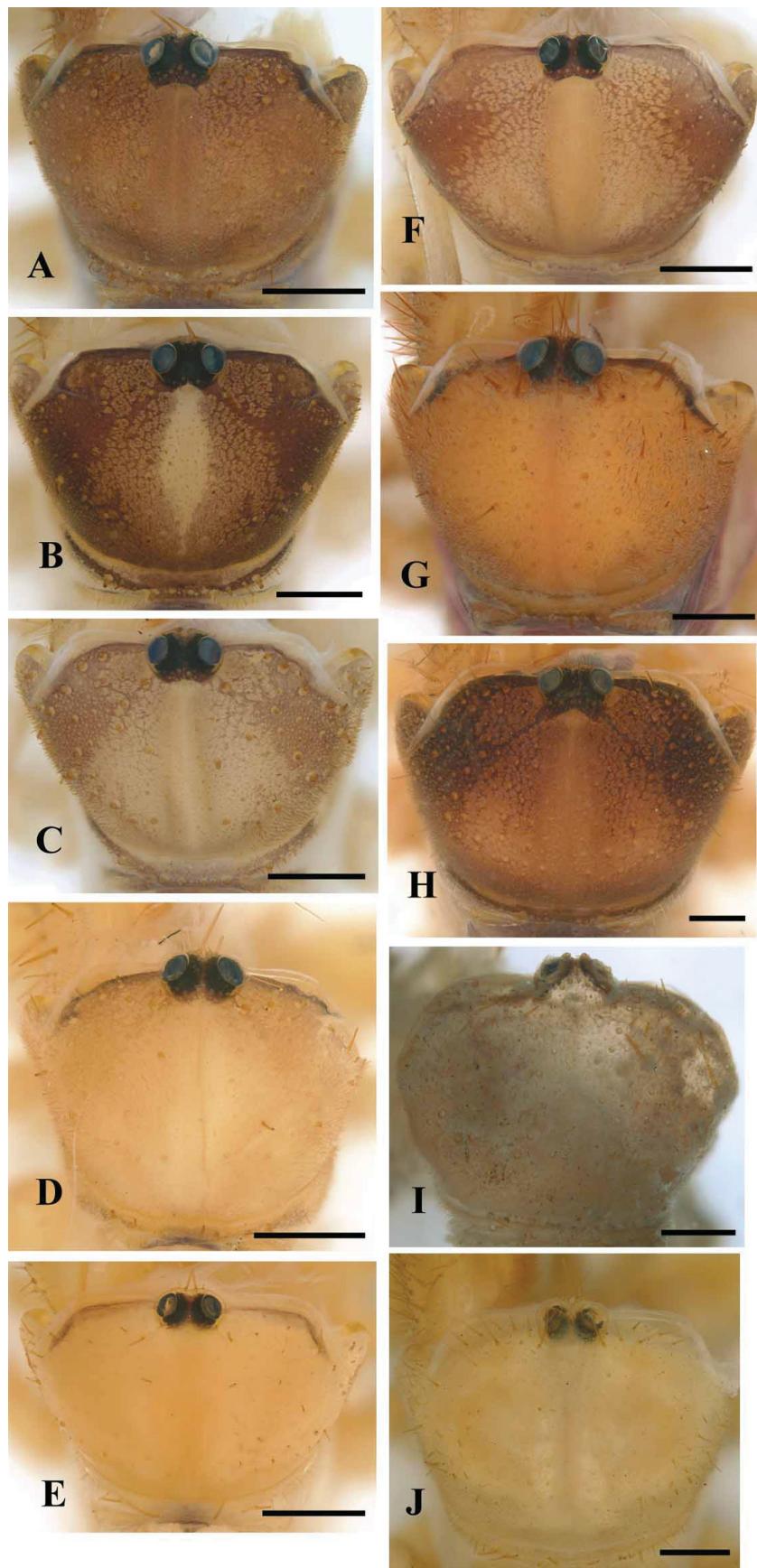


FIGURE 3. Propeltidia of holotypes. Scale bars = 1.0 mm. A) *Eremobates axacoa*. B) *Eremobates bonito*. C) *Eremobates cyranoi*. D) *Eremobates fisheri*, male holotype. E) *Eremobates fisheri*, female allotype. F) *Eremobates hidalgoana*, female holotype. G) *Eremobates jaliscoana*. H) *Eremobates minamoritaana*. I) *Eremobates zacatecana*. J) *Eremobates zapal*.

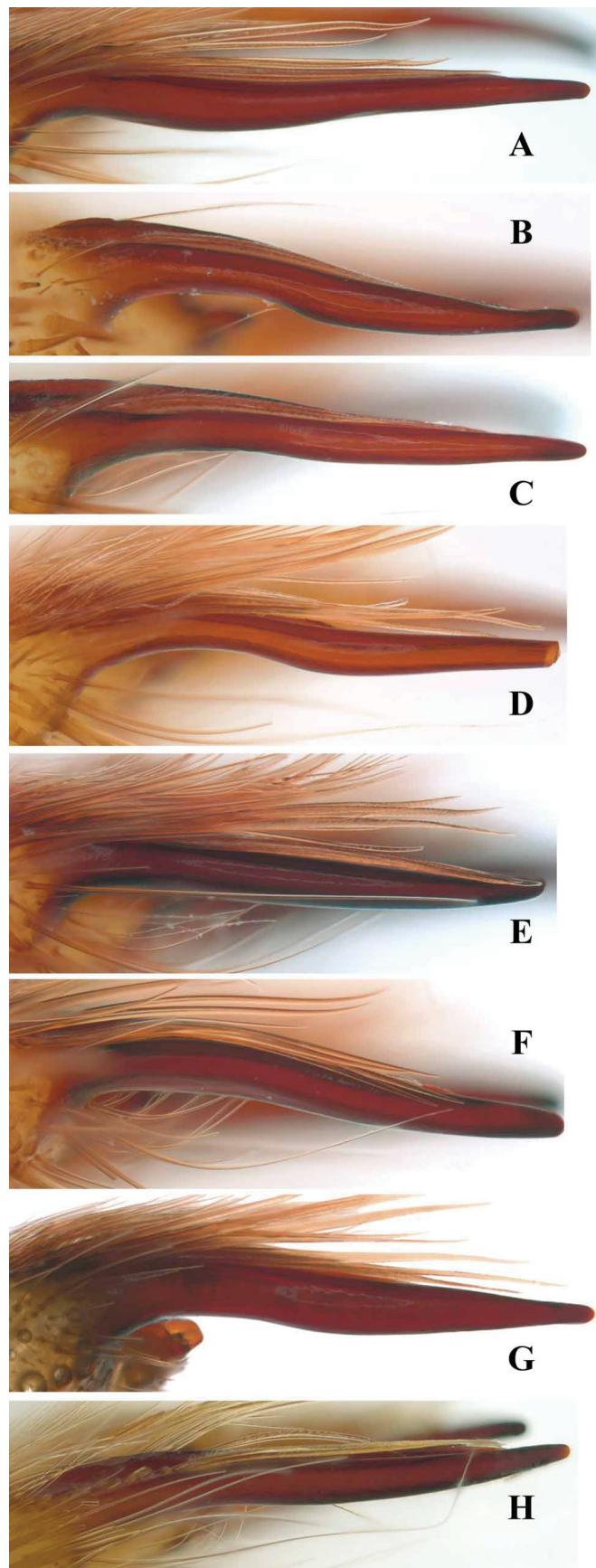


FIGURE 4. Dorsal views of cheliceral fixed fingers of male holotypes showing the basal notch. See Fig. 5 for scale. A) *Eremobates axacoa*. B) *Eremobates bonito*. C) *Eremobates cyranoi*. D) *Eremobates fisheri*. E) *Eremobates jaliscoana*. F) *Eremobates minamoritaana*. G) *Eremobates zacatecana*. H) *Eremobates zapal*.

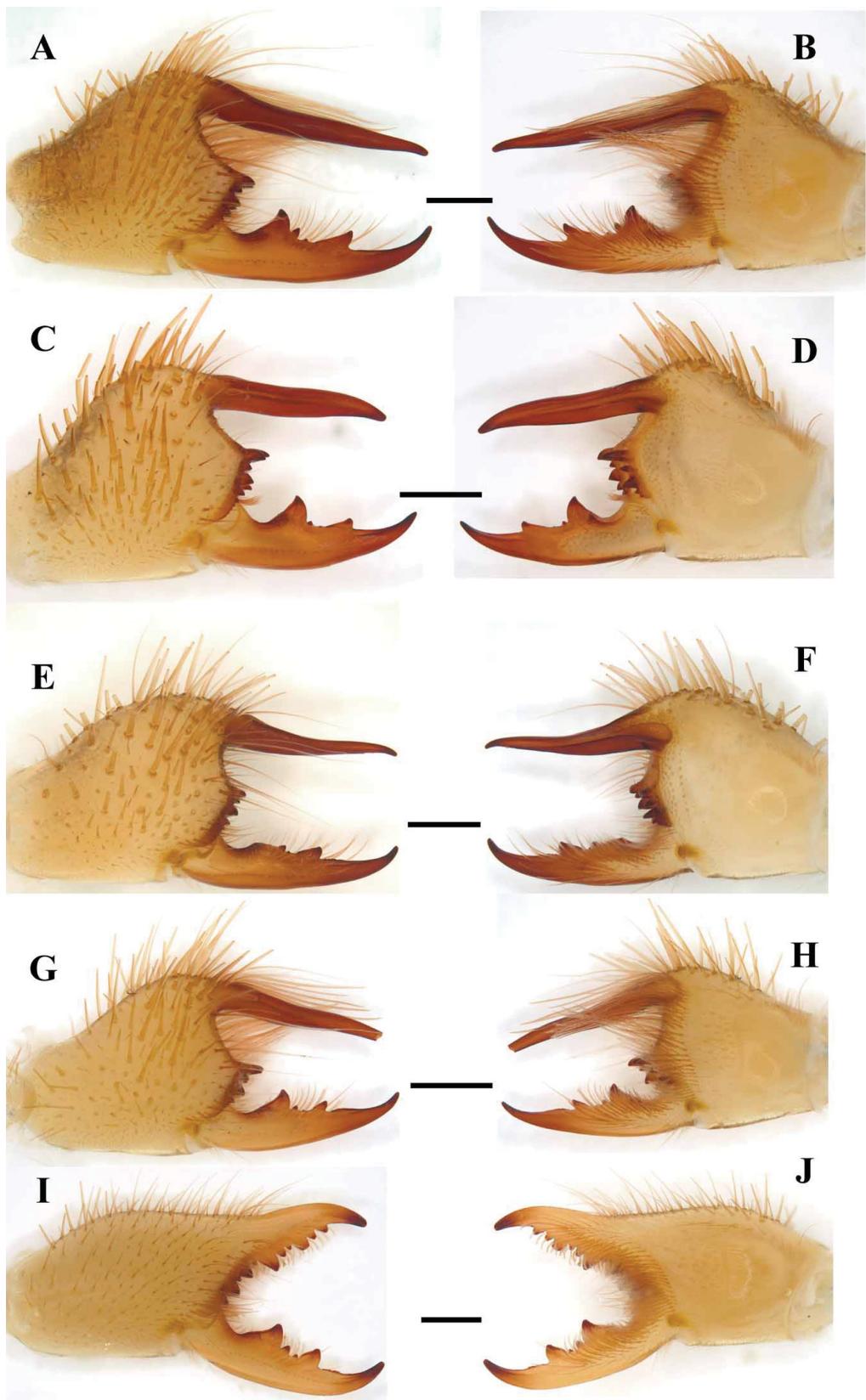


FIGURE 5. Retrolateral (left) and prolateral (right) cheliceral views of holotypes (and one allotype). Scale bars = 1.0 mm. A & B) *Eremobates axacoa*. C & D) *Eremobates bonito*. E & F) *Eremobates cyranoi*. G & H) *Eremobates fisheri*, male holotype. I & J) *Eremobates fisheri*, female allotype. K & L) *Eremobates hidalgoana*, female holotype. M & N) *Eremobates jaliscoana*. O & P) *Eremobates minamoritaana*. Q & R) *Eremobates zacatecana*. S & T) *Eremobates zapal*.

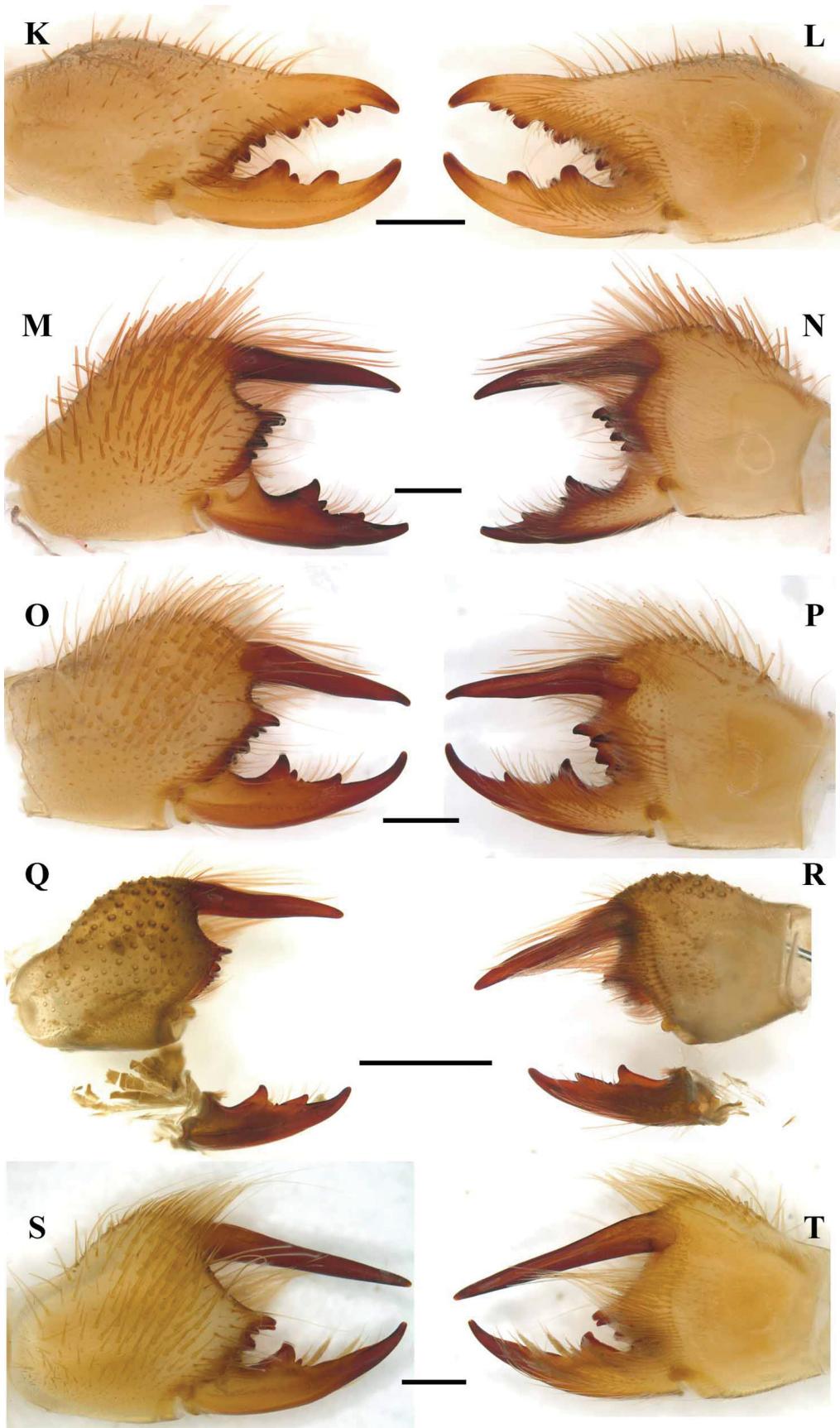


FIGURE 5. (Continued)

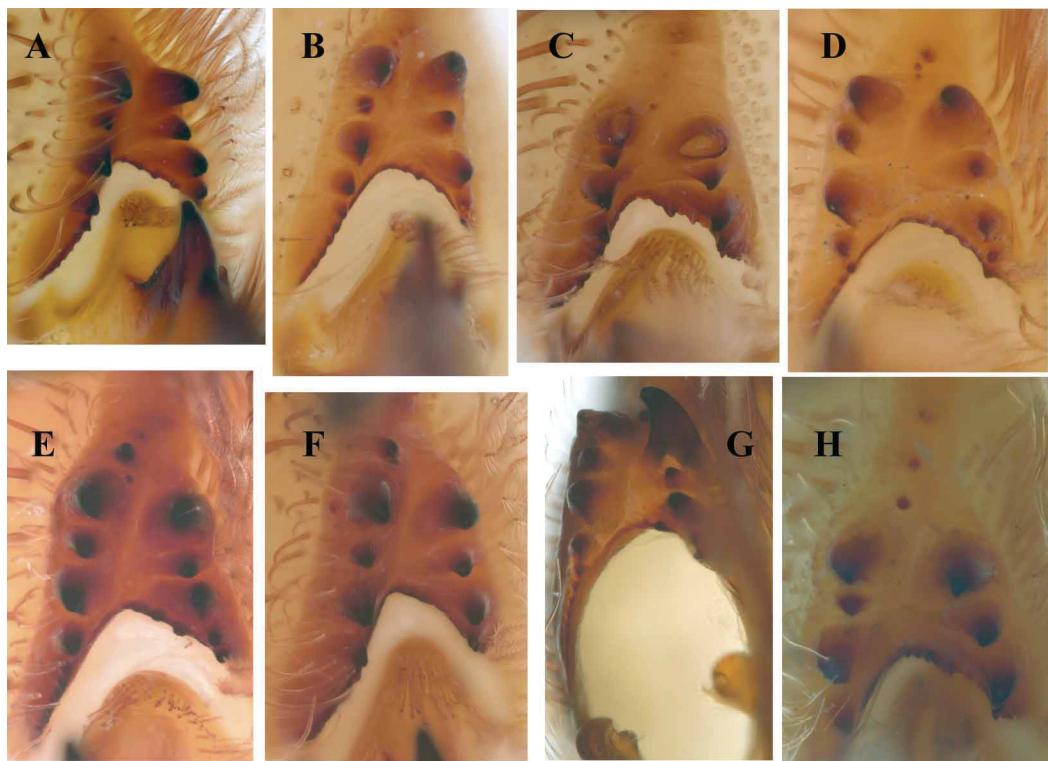


FIGURE 6. Fondal teeth on fixed fingers of male holotypes. See Fig. 5 for scale. A) *Eremobates axacoa*. B) *Eremobates bonito*. C) *Eremobates cyranoi*. D) *Eremobates fisheri*. E) *Eremobates jaliscoana*. F) *Eremobates minamoritaana*. G) *Eremobates zacatecana*. H) *Eremobates zapal*.

Etymology. A Spanish word referencing the beautiful color pattern. A noun in apposition.

Diagnosis. Distinctive color pattern of the propeltidium (Fig. 3B) and appendages, combination of ctenidial shape and presence of scattered palpal papillae are distinctive (Figs. 7A, 8A). Males differ from those of *E. cyranoi* n. sp. in the shape of the fixed finger, size of fondal teeth, and the shorter FNH (Figs. 5C & D, Fig. 6B).

Description. *Male holotype. Coloration.* Palpal tarsus, metatarsus, tibia dark brown (Fig. 7A illustrates dark tarsus and metatarsus); apical half of femur lighter brown; femur of legs I and II lighter brown, leg III tibia-femoral joint light brown, proximal half of tibia and distal half of femur of leg IV dark brown. Propeltidium dark brown with a pale cream narrow oval extending posteriorly from the ocular tubercle (Fig. 3B). Abdominal tergites dark brown dorsally and grayish-cream colored ventrally. Malleoli white.

Measurements. Male holotype. TL 20.5; CL 5.0; CH 2.7; FNL 0.6; FNH 0.5; FFH 0.4; PL 18.0; PT 1.3; PMT 5.0; LI 10.0; LIV 20.0; PPL 2.8; A/CP 6.1; CL/CH 1.9; FNL/FNH 1.2; FFH/FNH 1.2; PMT/PT 2.5.

Chelicera. Fixed finger typical; movable finger with large MP, two small MSM, separate from MP, typical flattened MM with no cleft (Figs. 5C & D). Fondal teeth graded I, III, II, IV retrolaterally and prolaterally (Fig. 6B). There is a small tooth ventral to fondal tooth IV retrolaterally (Fig. 6B). Deep MVG similar to *E. cyranoi* but in a more level trajectory (Fig. 5D). Sharply pointed MPL (Fig. 5D). No visible RFA; three RF. Cheliceral setal pattern: *pvd* typical, fondal plumose setae extend to top of fondal notch; *mpd* layer extends to MM.

Setation. Approximately 20 scattered palpal papillae on metatarsus (Fig. 7A); 4 short peg-like ctenidia (Fig. 8A). Numerous bifid bacilli on coxae of legs II, III, IV.

Eremobates cyranoi n. sp

Figs. 3C, 4C, 5E & F, 6C, 8B

Type material. Mexico: Coahuila, 9 km al sur de la casita, Sierra de la Concordia Municipio. General Cepeda. N 25.14382°, W 101.45730°. 23 July 2006. Coll. O.F. Francke, *et al.* Holotype male deposited at IBUNAM (CNAN-T1010).

Etymology. Referencing the twisted upturned fixed finger reminiscent of the reputed nose of Edmond Rostrand's Cyrano de Bergerac.

Diagnosis. The dorsal orientation of the MVG, the short FNH, short fondal teeth, and the graceful upturned male fixed finger distinguishes this species from others (Figs. 4C, 5E & F, 6C). Males of *Eremobates corpink* and *E. scaber* also have upturned fixed fingers but each possesses two short ctenidia versus the four thin ctenidia found on *E. cyranoi* (Fig. 8B).

Description. *Male holotype. Coloration.* Overall pale, palps dark on tarsus and metatarsus; legs I, II, III, IV light; propeltidium overall blotchy, dusky violet-brown, darker on the edge, faint pale circular area behind ocular area, faint pale circular pattern on lateral edges of ocular area (Fig. 3C); abdomen dark dorsally, pale yellow ventrally.

Measurements. Male holotype. TL 22.0; CL 5.9; CH 2.5; FNL 0.4; FNH 0.6; FFH 0.6; PL 17.0; PT 1.3; PMT 4.1; LI 13.5; LIV 25.0; PPL 2.5; A/CP 6.6; CL/CH 2.4; FNL/FNH 0.7; FFH/FNH 1.1; PMT/PT 3.3.

Chelicera. Fixed finger upturned (Figs. 5E & F); typical *scaber* MVG, deeper than usual, heading dorsally proximally, ending at the cheliceral tip (Fig. 5F). Typical *scaber* fixed finger. Movable finger damaged but apparently with large MP, MSM in notch, smaller MSM, larger than typical MM, no cleft under MM (Figs. 5E & F). MPL visible (Fig. 5F). Fondal teeth graded I, III, II, IV retrolaterally and prolaterally; no RFA; 2 RF (Fig. 6C). Cheliceral setal pattern: typical plumose *pvd*, plumose setae extend to fondal tooth I; *mpd* extends past MM.

Setation. No palpal papillae; four sword-shaped ctenidia extending half the length of the succeeding sternite (Fig. 8B). Palp without paired setae on tibia, scattered setae on distal end of femur. No visible bacilli on coxae.

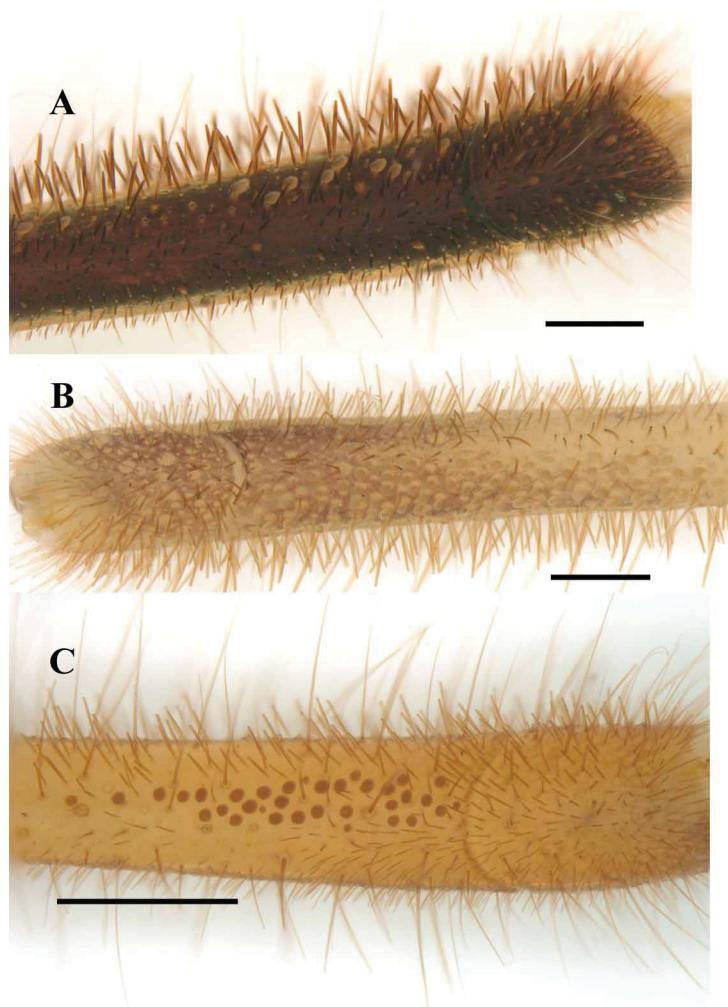


FIGURE 7. Fields of palpal papillae on the tarsal and metatarsal segments of male holotypes. Scale bars = 0.5 mm. A) *Eremobates bonito*. B) *Eremobates fisheri*. C) *Eremobates jaliscoana*.

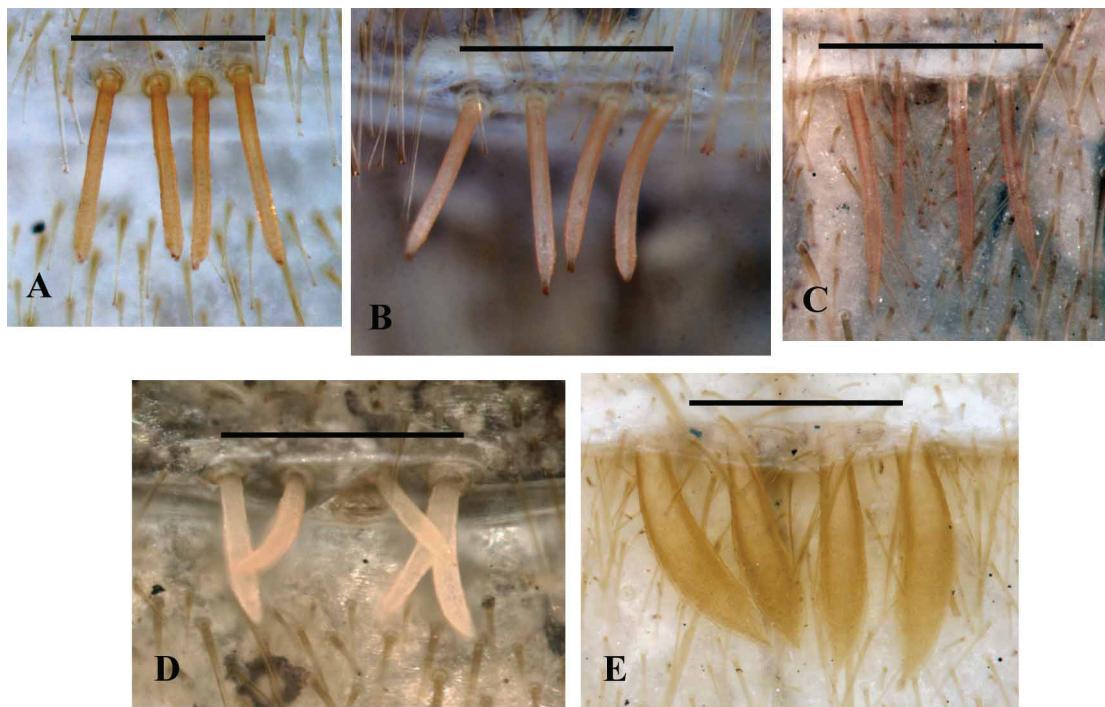


FIGURE 8. Ctenidia on post-genital sternite of male holotypes. Scale bars = 0.5 mm. A) *Eremobates bonito*. B) *Eremobates cyranoi*. C) *Eremobates fisheri*. D) *Eremobates jaliscoana*. E) *Eremobates zapal*.

***Eremobates fisheri*, n.sp.**

Figs. 3D & E, 4D, 5G–J, 6D, 7B, 8C, 9A

Type material. *Male Holotype* (DMNS ZA.34828). USA: California: Kern Co. Dove Springs, Array #29, N 35.4233°, W 118.0192°. August 2004. Coll. USGS, San Diego. *Female Allotype* (DMNS ZA.34829), California: Kern Co. Dove Springs; N 35.41043°, W 118.00674°; August 2004. Coll. USGS, San Diego. *Male Paratype* (DMNS ZA.34831). USA: California: Kern Co. Dove Springs, Array #7, N 35.439°, W 118.0173°; June 2003. Coll. USGS, San Diego. *Male Paratype* (DMNS ZA.34833). USA: California: Kern Co. Dove Springs, Array #35, N 35.415°, W 118.0308°; August 2003. Coll. USGS, San Diego. *Female Paratype* (DMNS ZA.34830). USA: California: Kern Co. Dove Springs, Array #30, N 35.4255°, W 118.0238°. June 2003. Coll. USGS, San Diego. *Female Paratype* (DMNS ZA.34832). USA: California: Kern Co. Dove Springs, Array #1, N 35.4164°, W 118.0033°; June 2003. Coll. USGS, San Diego. *Female Paratype* (DMNS ZA.34834). USA: California: Kern Co. Dove Springs, Array #3, N 35.4224°, W 118.0038°; September 2003. Coll. USGS, San Diego. *Female Paratype* (DMNS ZA.34835). USA: California: Kern Co. Dove Springs, Array #3, N 35.4224°, W 118.0038°; August 2004. Coll. USGS, San Diego. *Female Paratype* (DMNS ZA.34836). USA: California: Kern Co. Dove Springs, Array #6, N 35.4337° W 118.0176°. Coll. USGS, San Diego.

Etymology. Named for Robert Fisher of the USGS, San Diego branch who directed the collection of these specimens from Dove Springs, California as well as over 500 adult solifuges from Southern California, many of which were used for the study by Cushing *et al.* (2015).

Diagnosis. Males of this species are separated from *E. icenoglei* by the presence of a medial tooth, four ctenidia, and lighter coloration (Figs. 5G & H, 8C). Brookhart & Cushing (2004) suggested that the northern California species identified there as *E. ascopulatus* might be a different species. We now suspect those northern California specimens are actually *E. fisheri*.

Description. *Male Holotype. Coloration.* Overall tan-yellow; appendages lighter yellow; palp with tinge of violet-brown on tarsus and apical end of metatarsus; legs III and IV yellow, slightly darker at tibia-femoral joint; propeltidum yellow, darker on lateral edges (Fig. 3D). Abdomen yellow-grey dorsally and ventrally.

Measurements Male Holotype. TL 19.0; CL 4.8; CH 2.3; FNL 1.8; FNH 0.8; FFH 0.7; PL 17.5; PT 1.3; PMT 4.1; LI 12.0; LIV 22.5; PPL 2.5; A/CP 7.1; CL/CH 2.1; FNL/FNH 2.0; FFH/FNH 0.8; PMT/PT 3.3.

Measurements Two male paratypes. TL 18.0, 19.0; CL 4.8, 4.8; CH 2.3, 2.3; FNL 1.6, 1.8; FNH 0.8, 0.8; FFH 0.6, 0.7; PL 16.5, 17.5; PT 1.3, 1.3; PMT 4.1, 4.1; LI 12.0, 13.0; LIV 22.5, 20.5; PPL 2.5, 2.5; A/CP 7.1, 7.3; CL/CH 2.1, 2.0; FNL/FNH 2.0, 2.0; FFH/FNH 0.8, 0.7; PMT/PT 3.3, 3.3.

Chelicera. Male Holotype. Fixed finger typical, curved proximally in dorsal view; edge straight dorsally and slightly upturned distally on the ventral edge (Figs. 4D, 5G & H). Movable finger with large proximal tooth, 1 large MSM separate from MP, smaller MSM, typical *scaber* MM with cleft, tiny MPL tooth (Figs. 5G & H). FNL > FNH. MVG typical of *E. scaber* species group, deep and medially situated. Fondal teeth graded I, III, II, IV retrolaterally and prolaterally; 3 RFA; 3 RF (Fig. 6D). Cheliceral setal pattern: typical eremobatid setal pattern; dorsal cheliceral setation (*pvd*) typical, fondal plumose setae (*pvd*) extend to top of fondal tooth I; *mpd* plumose setae extend to the anterior of MM.

Setation. Male holotype. The medial surface of the palpal metatarsus displays 80–100 scattered palpal papillae (Fig. 7B). There are four ctenidia extending half the length of the succeeding sternite (Fig. 8C). Thinly scattered bifid setae on coxae of legs II and III. No paired setae on palpal tibia, scattered thin setae distally on palpal femur.

Female Allotype. Overall light yellow. Propeltidium uniformly yellow (Fig. 3E). Appendages yellow except for violet-brown tinge on the palpal tarsus and apical end of metatarsus. Genital operculum: narrow anterior arms, similar to *Eremobates icenoglei* (Brookhart & Cushing 2004) and a hooked posterior end similar to *Eremobates socal* (Brookhart & Cushing 2004) (Fig. 9A).

Measurements (Allotype). TL 22.5; CL 6.4; CH 2.3; PL 17.5; PT 1.7; PMT 3.7; LI 10.0; LIV 21.5; PPL 2.5; A/CP 5.3; CL/CH 2.8; PMT/PT 2.2.

Measurements (5 female paratypes, ranges). TL 15.0–22.5; CL 5.4–6.4; CH 2.3–2.4; PL 14.0–17.0; PT 1.1–1.6; PMT 2.8–3.8; LI 9.5–12.0; LIV 16.0–21.5; PPL 2.2–2.5; A/CP 4.9–5.4; CL/CH 2.3–2.7; PMT/PT 2.2–2.8.

Chelicera (Allotype). Typical fixed finger with prominent RFA, large MP, large FSM, small FSM, medium FSD, large FD. Movable finger with large MP, large MSM, small MSM, MM, MPL visible (Figs. 5I & J), 3 RF. Cheliceral setal pattern: typical with *pvd* and *mpd* combination setae extending from FD of fixed finger to MM of movable finger.

Eremobates hidalgoana n.sp

Figs. 3F, 5K & L, 9B

Type material. Mexico: Hidalgo, San Juan, “en plantios de maguey” (in agave plantations). 4 July 1970. Coll. Ramerez. No other data. Holotype female and one female paratype (both in same vial) deposited at IBUNAM (CNAN-T1013).

Etymology. Referencing the type locality.

Diagnosis. Shape of female genital operculum is distinctive as is the color pattern. *Eremobates mormonus* has a similar genital operculum; however, the distal “wings” of the genital opercular plates of *E. hidalgoana* are narrower than the broader wings of *E. mormonus* (compare Fig. 9B with fig. 57 from Brookhart & Cushing 2004). In addition, the inner margins of the sclerotized wings of *E. hidalgoana* and *E. mormonus* are both recurved; however, the concavity of the curvature is more pronounced in *E. mormonus*. In addition, *E. mormonus* is found in the southwestern United States; geographically separate from the apparent range of *E. hidalgoana*.

Description. Female holotype. *Coloration.* Chelicera and propeltidium yellow-orange, abdomen grey with violet-brown rectangles dorsally; plain grey ventrally; palps violet-brown on tarsus, metatarsus, tibia, distal dorsal region of the femur. Legs II, III, IV violet-brown dorsally on tibia and femur. Propeltidium patchy violet-brown, darker on the edges, lighter circular area extending from anterior edge to posterior edge of propeltidium (Fig. 3F). *Genital operculum.* Short, thick anterior arms, recurved inner margin (Fig. 9B) resembling *E. mormonus* (Roewer 1934) (see fig. 57 in Brookhart & Cushing 2004).

Measurements. Female holotype. TL 22.5; CL 5.0; CH 2.2; PL 13.0; PT 1.8; PMT 5.0; LI 12.0; LIV 15.5; PPL 2.5; A/CP 5.4; CL/CH 2.3; PMT/PT 2.5.

Measurements. Female paratype. TL 14.5; CL 5.3; CH 2.3; PL 11.0; PT 1.1; PMT 5.0; LI 10.0; LIV 17.0; PPL 2.2; A/CP 5.1; CL/CH 2.3; PMT/PT 2.5.

Chelicera. Dentition typical fixed finger with large FP, small FSM, large FM, small FSD, small FD; movable finger with large MP, large MSM (in the notch), tiny MSM, large MM (Figs. 5K & L). Fondal teeth graded II, I, III, tiny IV retrolaterally I, III, II, tiny IV prolaterally; MPL not visible; 2 RFA; 2 RF. Cheliceral setal pattern: typical with inner setal rows *pvd* & *mpd* plumose dorsally, prolaterally, and ventrally (see Bird *et al.* 2015, plate 12 A).

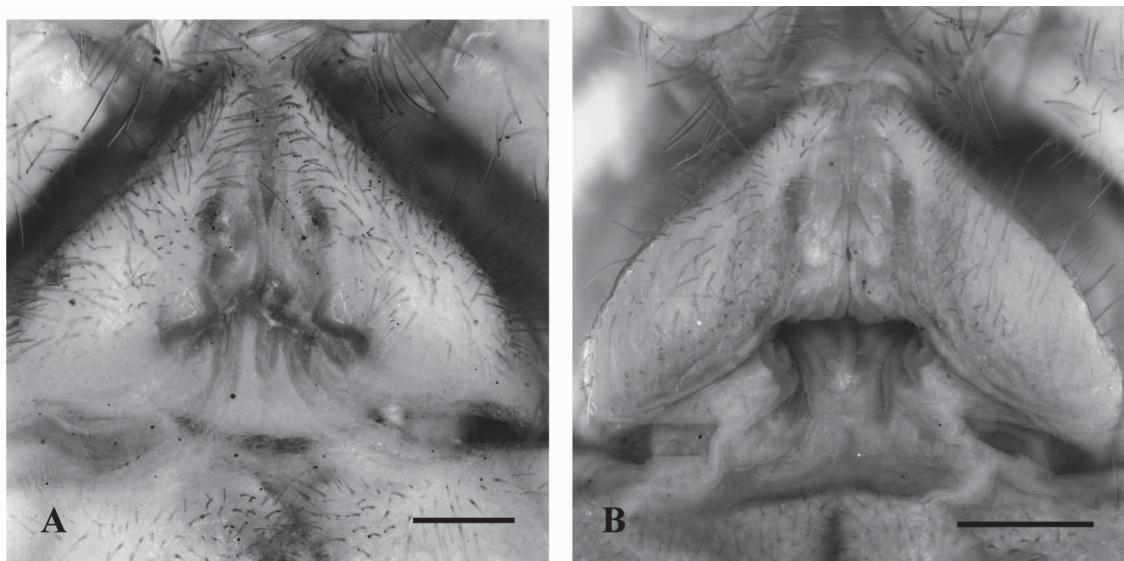


FIGURE 9. Genital opercula. Scale bars = 0.5 mm. A) *Eremobates fisheri*, female allotype. B) *Eremobates hidalgoana*, female holotype.

Eremobates jaliscoana n. sp.

Figs. 3G, 4E, 5M & N, 6E, 7C, 8D

Type material. Mexico: Zapopan, Nextipac (near the main road), N 20.452889°, W 103.33255°. No other data. Holotype male deposited at IBUNAM (CNAN-T1008).

Etymology. Referencing the type locality.

Diagnosis. *Eremobates jaliscoana* is similar to *E. similis* in the number and shape of the ctenidia and palpal papillae; however, *E. jaliscoana* can be distinguished by differences in overall body coloration, size of ctenidia, shape of the fondal notch, and curvature of the proximal region of the fixed finger.

Description. *Male Holotype. Coloration.* Overall dark coloration; chelicera, propeltidium, appendages dusky amber, abdomen grey, amber dorsally and ventrally. Malleoli white. Inner two malleoli lightly tinged (possibly an artifact of preservation).

Measurements. TL 22.0; CL 6.1; CH 2.8; FNL 1.0; FNH 0.6; FFH 0.5; PL 12.0; PT 1.6; PMT 4.3; LI 13.5; LIV 21.0; PPL 3.0; A/CP 5.1; CL/CH 2.2; FNL/FNH 1.6; FFH/FNH 1.3; PMT/PT 2.7.

Chelicera. Fixed finger basal notch in dorsal view not as evident as a typical *scaber* (Fig. 4E), fixed finger straight with slight apical hook (Figs. 5M & N); movable finger MP large, MSM in the notch, tiny MSM, typical MM, no cleft (Figs. 5M & N). Typical *scaber* MVG, prolaterally located and deep (Fig. 5P). Fondal teeth graded retrolaterally and prolaterally I, III, II, IV with an additional tiny tooth ventral to IV; one large and two tiny RFA; 2 BF (Fig. 6E). FNL > FNH (Fig. 5M). Cheliceral setal pattern with fondal plumose setae (*pvd*) extending to top of fondal notch; *mpd* layer extends to MP.

Setation. Four short ctenidia (Fig. 8D), approximately 30 palpal papillae located distally on metatarsus (Fig. 7C); no paired setae on palpal tibia. No visible bacilli on coxae of legs II, III, IV.

Eremobates minamoritaana n. sp.

Figs. 3H, 4F, 5O & P, 6F

Type material. Mexico: Chihuahua, Ascension. Mina la Morita. 29 August 2008. Coll. Paul Bryant. Holotype male deposited at IBUNAM (CNAN-T1011).

Etymology. Referencing the type locality.

Diagnosis. Among the darker members of this group. The chelicera is wider at the base, similar to *E. hodai*, which is found in the northwestern United States, geographically isolated from *E. minamoritaana*. *Eremobates actenidia* and *E. ctenidiellus* also lack ctenidia, similar to *E. minamoritaana* but, unlike this species, both have palpal papillae, absent in *E. minamoritaana*. No females were examined.

Description. *Male holotype. Coloration.* Overall dark body, appendages pale. Propeltidium dark with mottled markings (Fig. 3H), similar to *E. bonito* (Fig. 2B). Abdominal tergites pale grey ventrally.

Measurements. TL 27.0; CL 5.8; CH 3.1; FNL 0.7; FNH 0.5; FFH 0.5; PL 21.5; PT 1.6; PMT 4.4; LI 14.0; LIV 21.0; PPL 3.1; A/CP 6.3; CL/CH 1.9; FNL/FNH 1.5; FFH/FNH 1.0; PMT/PT 3.3.

Chelicera. Fixed finger straight with a wider base (Fig. 5O & P); ventral edge slightly undulate. Movable finger with large MP; MSM tooth in the notch; smaller MSM distally; MM smaller with no cleft below (Figs. 5O & P). Typical eremobatid MVG, deep and more dorsally oriented (Fig. 5P). Fondal teeth II, III, IV small, graded I, III, II, IV retrolaterally and prolaterally; long fondal notch; one small RFA; RF minute or absent (Fig. 6E). Cheliceral setal patterns: typical dorsal *pvd*, fondal plumose setae *pvd* extending to the top of the fondal notch; inner *mpd* plumose bristles extend to MM.

Setation. No palpal papillae or ctenidia. No paired setae on palpal tibia, small scattered patch on distal inner edge of femur. Malleoli white. Numerous bifid bacilli on coxae of legs II, III, IV.

***Eremobates zacatecana*, n. sp.**

Figs. 3I, 4G, 5Q & R, 6G

Type material. Mexico: Zacatecas, Km 184.5 Carretera Sombrerete-Durango, N 23.74532°, W 103.74632°. Elev. 2357 m. 9 Aug 2005. Coll. Duran-Barron, Montaño, Sissom. Deposited at IBUNAM (CNAN-T1007).

Etymology. Referencing the type locality

Diagnosis. *E. zacatecana* may be sympatric with *E. cyrano* but can be separated by the coloration of appendages, shape of fondal notch and cheliceral dentition. Its dentition is also distinctive.

Description. *Male holotype. Coloration.* Specimen badly damaged. Apparently pale, palp darker on tarsus and metatarsus.

Measurements. TL 21.0 (estimate); CL 5.3 CH 2.8; FNL 0.5; FNH 0.5; FFH 0.5. Appendages damaged, therefore no: PL, LI, LIV, or A/CP possible. PT 1.6; PMT 4.0; PPL 3.5; CL/CH 1.9; FNL/FNH 1.1; FFH/FNH 1.0; PMT/PT 2.5

Chelicera. Fixed finger typical; straight, broad, short (Fig. 5Q & R). Movable finger with MP, MSM in notch, typical MM, no cleft, MPL tiny. MVG typical (Figs. 5R). Fondal teeth typical I, III, II, IV retrolaterally and prolaterally plus additional smaller tooth ventrally on prolateral surface; no visible RFA; 2 RF (Fig. 6G). Cheliceral setal pattern: Flagellar complex typical; fondal plumose setae (*pvd*) extend to fondal tooth I; no *mpd* plumose layer but a *mff* proximal patch.

Setation: No visible papillae or ctenidia. No paired setae on palpal tibia; tiny, sparse setal patch on distal region of palpal femur. Malleoli white.

***Eremobates zapal*, n. sp.**

Figs. 3J, 4H, 5S & T, 6H, 8E

Type material. Mexico: Baja California Sur, La Paz. 5 July 1946. No other data. Deposited at IBUNAM (CNAN-T1009).

Etymology. Anagram of type locality, La Paz.

Diagnosis. Pale coloration, shape of ctenidia, thickness of fixed finger, lack of pigmentation around the eye tubercle (this may be an artifact) distinguish this species from others. This is the first *E. scaber* species group solifuge to have been found on the Baja, California peninsula.

Description. *Male holotype. Coloration.* Overall pale yellow; chelicera slightly darker; appendages pale

yellow. Propeltidium light yellow; eye tubercle same color (Fig. 3J). Abdomen with broad, light violet-brown stripe dorsally and grey ventrally.

Measurements. TL 23.0; CL 6.3; CH 3.1; FNL 1.3; FNH 0.9; FFH 0.6; PL 19.0; PT 1.3; PMT 4.5; LI 15.0; LIV 22.0; PPL 2.8; A/CP 6.2; CL/CH 1.4; FNL/FNH 1.5; FFH/FNH 1.5; PMT/PT 3.6.

Chelicera. Fixed finger straight; MVG typical running medial on fixed finger (Fig. 5T); movable finger with large MP, small MSM, tiny MSM; MM a slight ridge with no cleft (Figs. 5S & T). Fondal teeth I, III, II, IV retrolaterally and prolaterally; two tiny RFA; 3 RF (Fig. 6H). Cheliceral setal pattern: dorsal setae typical; fondal plumose *pvd* extends to top of fondal notch; *mpd* extends to MP of movable finger.

Setation. No palpal papillae; 4 broad stubby sword shaped ctenidia (Fig. 8E). Malleoli pale. Numerous bifid bacilli on coxae of leg II, III, IV.

Discussion

Mexico is a biologically rich country (Mittermeier & Goetsch 1997; Bryson *et al.* 2012, Graham *et al.* 2014) having several distinct physiographic regions, each with its own evolutionarily distinct biota intersecting within the confines of the state borders (Morrone 2006). Material from the Chihuahuan Desert suggests that the solifuge fauna of this region is diverse. We expect more new species of eremobatids to be discovered from this vast, under-explored desert.

Recent work by Cushing *et al.* (2015) discusses eremobatid diversity as a function of desert formation and orogeny. The complex geologic forces that formed the Chihuahuan Desert and other biomes in northern Mexico may have led to the high diversity of desert adapted arachnids. Since all of the new Mexican species were the result of serendipitous acquisition by researchers looking for different groups or by interested citizens bringing them to IBUNAM for identification, it seems likely that a more systematic search might yield a series of specimens and more species.

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